SILOXANE COPOLYMERS FOR OPHTHALMIC APPLICATIONS

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BACKGROUND OF THE INVENTION

The present invention relates to a class of novel siloxane monomers containing both an aromatic ring and vinyl functionality. Polymers comprising variable amounts of these monomers are transparent to visible light, have a high refractive index, and are useful, inter alia in fabricating lenses, especially contact lenses and intracameral devices such as corneal inserts and intraocular lenses. Contact lenses generally are fillerless, oxygen transportable, hydrolytically stable, biologically inert, transparent plastic bodies which are prepared from polymerization, or copolymerization of monomers. This invention describes a new monomer, which is a siloxane monomer containing both an aromatic ring and vinyl functionality.

The polymers and copolymers described herein can be usefully employed for making "hard" or "soft" contact lenses, intraocular implants, intracorneal implants, semisoft contact lenses, as well as in other biomedical applications. Importantly, the polymers of this invention, when properly copolymerized with other materials have wide adaptability and compatability with other monomers. They are therefore versatile and can be adapted to prepare good hard lenses, as well as good soft lenses. They may also have other uses such as permeable films, etc., but the primary description given will emphasize the lens utility.

Hard contact lenses have the advantages of excellent machinability, excellent stability, and excellent visual clarity. However, hard contact lenses have their disadvantages, as well. Generally for many, including the most common hard lenses, i.e. those made of polymethyl methacrylate (PMMA), oxygen permeability is low and the hydrophilic properties are poor.

It is important and essential that the cornea have access to atmospheric oxygen in order that an oxygen-carbon dioxide exchange can occur. Put another way, without constant eye exposure to the atmosphere, a state of oxygen edema can occur within the eye, which is potentially capable of causing damage. Thus, hard contact lenses, while having many practical advantages, generally are not altogether satisfactory because they most often have poor oxygen permeability.

A good hard contact lens would have not only excellent oxygen permeability, but also excellent tear-fluid wettability. Wettability is important in that if the lens if not wettable it cannot be comfortably worn in the eye. The patient will perceive the lens as uncomfortable and scratchy, absent good wettability.

Recently soft contact lenses have captured a significant market share. However, soft contact lenses are also not without disadvantages. Soft contact lenses generally have excellent oxygen permeability, and excellent eye comfort. However, soft lenses also readily attract and accumulate foregoing debris, necessitating frequent cleaning. Accordingly, both soft lenses and hard lenses, including gas permeable hard lenses, have their respective advantages and disadvantages.

Generally, in the past, polymer formulation for optical lens products has involved an initial determination as to whether one was formulating either a hard lens or a soft lens, followed by formula manipulation within a distinctly different class of monomers useful for one type, but not necessarily useful for the other. The monomers of the present invention, however, can be used for making either hard or soft lenses.

Indeed, it is an object of the present invention to provide a novel class of siloxane monomers characterized by containing both an aromatic ring functionality and vinyl functionality at certain stereo-directing positions, which can be employed as a monomer for preparing copolymers useful as materials for making a wide variety of types of optical products including hard lenses, soft lenses, and ocular implants.

A further object of the invention is to provide a monomer of the type specifically mentioned above which is not only of good oxygen permeability, but which is highly compatible with other monomers, and which, when copolymerized with other monomers provides wettability, without sacrificing oxygen permeability.

A still further object of the present invention is to provide hard gas permeable contact lenses which contain as a monomer of variable presence, the hereinafter defined class of monomers of the present invention.

A further object of the present invention is to provide soft contact lens of the hydrogel type which contain as a monomer of variable presence, the hereinafter defined monomer of the present invention.

A further object of the present invention is to provide a copolymerizable compound suited for preparing contact lenses which have good oxygen permeability, are machineable, and which can be used selectively for either hard or soft lenses, and which can be comfortably worn.

A still further object of the present invention is to prepare a monomer which can be copolymerized to provide a copolymer useful for optical products, particularly gas permeable hard contact lenses, wherein the copolymer has a DK, i.e. oxygen permeability constant value within the range of from about 12 to about 70, and which also has a highly wettable surface. Such lenses are comfortable, when worn show no evidence of substantial corneal edema, are of good machineability, are dimensionally stable, are tear wettable, and as well have suitable lipidic properties to optimally interact with tear fluid.

The method and means of accomplishing each of the above objectives, as well as others will become apparent from the detailed description of the invention which will follow hereinafter.

SUMMARY OF THE INVENTION

Certain siloxane monomers which contain both an aromatic ring and vinyl functionality are provided. The siloxane monomers can be used as a main monomer ingredient in providing copolymers useful for making either hard or soft contact lenses, or other optical products. The new siloxane monomers of the present invention provide excellent oxygen permeability in copolymers, without adversely impacting on other desirable properties such as machineability, wettability, lipophilicity, and dimensional stability. Moreover, a polymer, and copolymers containing it, are useful for making lenses which are substantially inert to the eye and transparent, and provide good visual clarity and sharpness of image. Such objectives are accomplished by a unique combination of functional groups in the monomer, selectively stereo-positioned on the monomer. In one preferred soft lens embodiment, the monomer of